

April 16, 1885.

THE TREASURER in the Chair.

The Presents received were laid on the table and thanks ordered for them.

The following Papers were read :—

- I. "Note on an Experiment by Chladni." By CHARLES TOMLINSON, F.R.S. Received March 14, 1885.

[PLATE 1.]

Lord Rayleigh, in a memoir "On the Circulation of Air in Kundt's Tubes," &c., remarks ("Proc. Roy. Soc.," xxxvi, 10, and "Phil. Trans.," 1884, Part I, p. 1) that "it was discovered by Savart that very fine powder does not collect itself at the nodal lines, as does sand in the production of Chladni's figures, but gathers itself into a cloud, which, after hovering for a time, settles itself over the places of maximum vibration."

In Savart's memoir, "Sur les Vibrations Normales" ("An. de Ch. et de Ph." for 1827, xxxvi, 187), the author distinctly claims the above-named discovery. At p. 190 he refers to the nodal lines of Chladni, but adds that by mixing with the sand a finer dust, such as lycopodium, "la poussière fine se réunit pour tracer d'autres lignes circulaires que ce physicien n'a pas connues," &c.

Faraday, in his critical examination of Savart's memoir ("Phil. Trans.," 1831, p. 299), apparently takes it for granted that Savart started with an original observation.

But this interesting discovery, which has been so fruitful in beautiful results, is really due to Chladni. In his "Traité d'Acoustique," Paris, 1809, he remarks, p. 125: "Si un peu de poussière fine est mêlée au sable, elle pourra mieux servir pour faire voir aussi les centres des vibrations, c'est-à-dire, les endroits où les parties vibrantes font les plus grandes excursions: les molécules les plus petites de la poussière s'accumuleront sur ces endroits."

Chladni is even more explicit in his "Neue Beyträge zur Akustik," (4to, Leipzig, 1817). At p. 7 he recommends "etwas *Pulvis lycopodii*" as the fine dust to be mixed with the sand; and at p. 69, he remarks that when fine dust accumulates on the centres of vibration, it is in heaps more or less round or long, &c., according to the form assumed by the vibrating part.

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When Wheatstone reproduced Chladni's figures on square plates ("Phil. Trans.," 1833, p. 593), he did not notice the remarkable figures produced by mixing a fine powder with the sand. This was the less necessary because Faraday's memoir had been so recently published, and its conclusion was so satisfactory, namely, that when a plate is vibrating, currents are established in the air lying upon the surface of the plate, which pass from the nodal lines towards the centres of maximum vibration, and then proceeding outwards from the plate to a greater or less distance, return towards the nodal lines.

With the exception of a very few elementary specimens on a small scale, as given by Chladni and Faraday, I am not aware that this class of figures has ever been adequately represented; and yet these figures are not only interesting in themselves, but are capable of being exhibited on a scale fitted for the lecture table. For some of the figures we may make use of a brass plate, 12 inches square, fixed on a pillar by means of a central screw. The upper surface of the plate should be blackened by means of nitrate of silver or chloride of platinum solution, or some such contrivance, so as to leave a stain not liable to crack or peel off.

A thin layer of sand is to be dusted over the surface by means of a pepper-box, and then a small bag of thin linen or calico, containing the lycopodium powder, is to be shaken over the layer of sand. On applying the bow to the edge of the plate, $3\frac{1}{4}$ inches from the corner, the note produced in my plate is $E\frac{1}{4}$ in the fourth space. This produces fig. 1 with well-defined nodal lines and heaps of lycopodium powder on the twelve centres of vibration. Under the continued action of the bow each heap expands, swells up, and contracts with great activity. If while this figure is at rest the bow be applied to the centre of the edge, so as to produce the higher note $B\flat$ above the lines in the treble clef, fig. 2 is produced, a figure of great beauty, from the symmetrical arrangement of its parts and the delicate variations of shading, which confer upon it an artistic character.

Iron filings were sifted over the plate, and on sounding the note that leads to the formation of fig. 1, the finest particles of iron were transferred to the centres of vibration, while the coarser remained at the nodes.

Lycopodium alone was dusted over the plate, when the powder became divided into two portions, one remaining on the nodal lines, now very much broader than those formed by sand, while a second portion assumed active functions on the vibrating centres. Lord Justice Fry, F.R.S., to whom I showed this experiment, suggested that the winnowing process which separated the finer from the coarser particles in the former experiments might also apply here. He collected specimens from the nodes and from the vibrating centres, but

on examination found that "the spores from both are of the same size, all being, I believe, macrospores." I have since examined a number of commercial specimens of lycopodium, but have not met with any containing microspores.

The powder of sublimed sulphur was also dusted over the plate, when on sounding the note E, fig. 1 was beautifully produced, the nodal lines being well defined, and not much coarser than with sand; but the flowers on the vibrating centres were much more diffused, shading off into cloudiness much more than with lycopodium. The sulphur also was not so active. Figs. 3 and 4 are attempts to represent the action of sulphur alone.

After a layer of iron filings had been sifted on the plate, a layer of sand was added, when the finer particles of iron did not escape to the vibrating centres, they being apparently imprisoned by the sand.

Flowers of sulphur being dusted on the plate, and then lycopodium, a certain amount of winnowing goes on under the influence of vibration, the sulphur for the most part going to the nodes, and the lycopodium to the centres (fig. 5). When either of these or a similar light powder is used alone, the slight adhesion of the powder to the plate on and about the nodal lines is sufficient to retain it there, while the looser upper particles are swept upon the centres.

The cyclonic air currents are well shown by flowers of sulphur, when the plate is thrown into its greatest amplitude of vibration by sounding either of the two lowest notes, D in the bass clef, and Ab below the lines of the treble clef, the figures being the well known crosses which terminate, one in the centre of the edges, and the other at the angles of the plate. In either case there are but four vibrating centres, and the powder occupies a considerable space on each, and is whirled round in numerous eddies, which can be distinctly followed by the eye, showing how the separate heaps of lycopodium are formed when this powder is used instead of sulphur, which does not collect in heaps, but in curved parallel ripples, convex towards the fixed centre of the plate.

The brass plate thus fixed yields but a limited number of figures. By using plates of various material and form, such as bell metal, bronze, white metal, glass, &c., in squares, parallelograms, ovals, &c., fixed at any point by means of Chladni's clamp, an endless variety of forms may be obtained. In the following figures the small white circle shows where the plate was clamped.

The presence of flowers of sulphur gives a softened effect to the figure, and converts the sharp angles formed by sand alone into graceful curves. Fig. 6 shows the effect of sulphur and lycopodium combined; fig. 7 of sand and lycopodium, where the finer powder collects in heaps. In the more complicated figures which follow it is remarkable to note the precision with which the lycopodium becomes sepa-

rated from the sand, and performs its evolutions within the numerous centres of vibration into which the plate breaks up.

With respect to the double circles (figs. 18 and 19), and the double ellipse (fig. 16), Chladni remarks that these are the most difficult of all the figures to produce. With the two powders, sand and lycopodium, the difficulty ceases, the lighter powder forming the outer and the sand the inner ring.

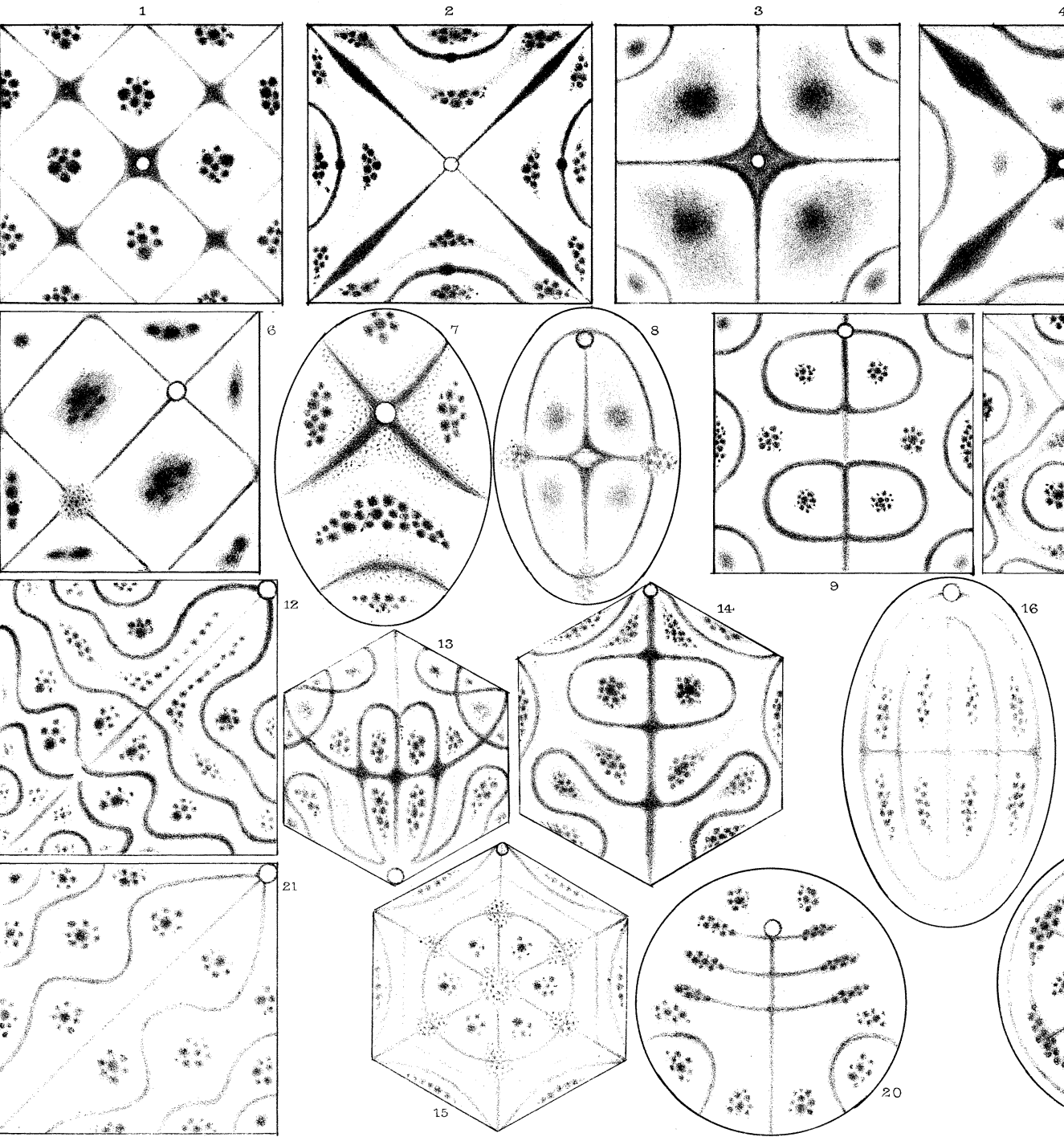
The figures represented have been faithfully copied from the plates; such distortions as those represented in fig. 10 are due to irregularities in the structure of the plate.

DESCRIPTION OF THE PLATE.

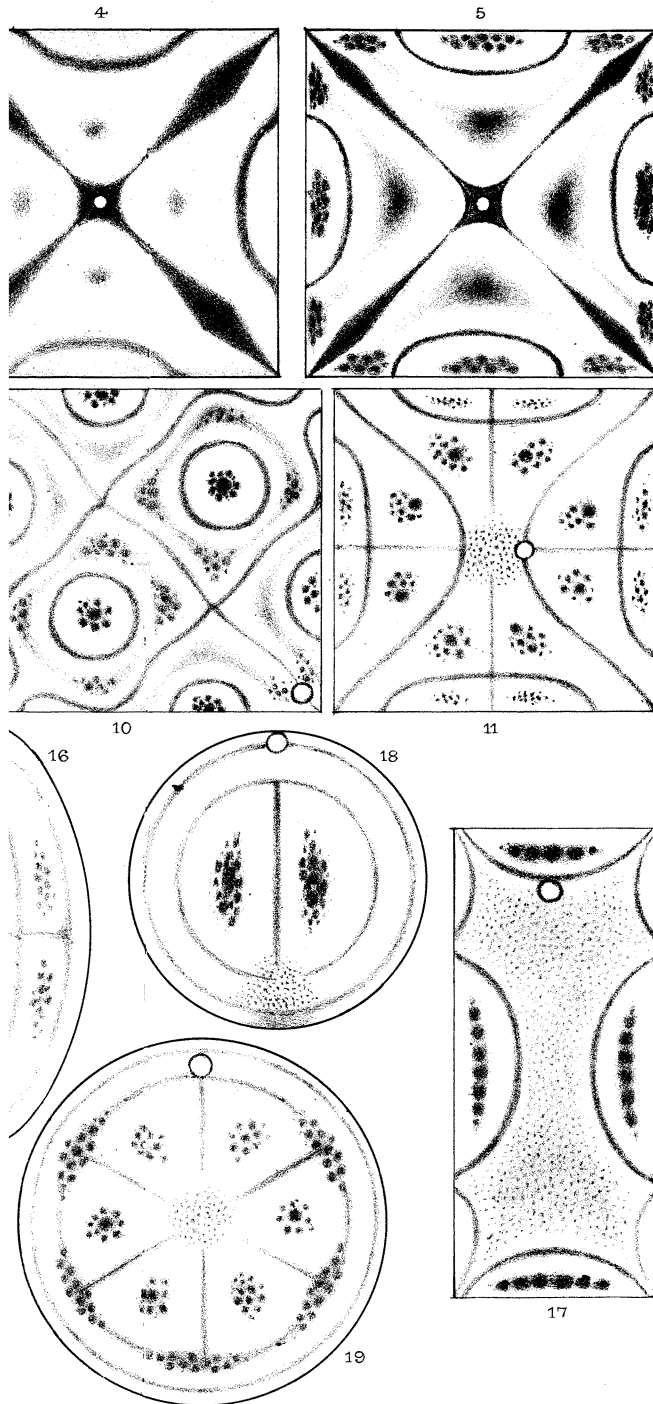
No. of Figure.	Material of the plate.	Dimensions.	Materials employed.
1.	Brass.	12 in. × 12 in.	Sand and lycopodium.
2.	"	"	" "
3.	"	"	Sulphur.
4.	"	"	" "
5.	"	"	Sulphur and lycopodium.
6.	Bronze.	8 in. × 8 in.	" "
7.	Brass.	{ Major axis, 7 in. Minor axis, 5 in. }	Sand and lycopodium.
8.	"	"	Sand and sulphur.
9.	White metal.	7 in. × 7 in.	Sand and lycopodium.
10.	Bell metal.	"	" "
11.	Brass.	"	" "
12.	"	8 in. × 8 in.	" "
13.	"	7 in. external diameter.	" "
14.	"	"	" "
15.	"	"	" "
16.	"	{ Major axis, 7 in. Minor axis, 5 in. }	" "
17.	"	8 in. × 4½ in.	" "
18.	Glass.	8 in. diameter.	" "
19.	"	9 in. diameter.	" "
20.	"	"	" "
21.	Bell metal.	7 in. × 7 in.	" "

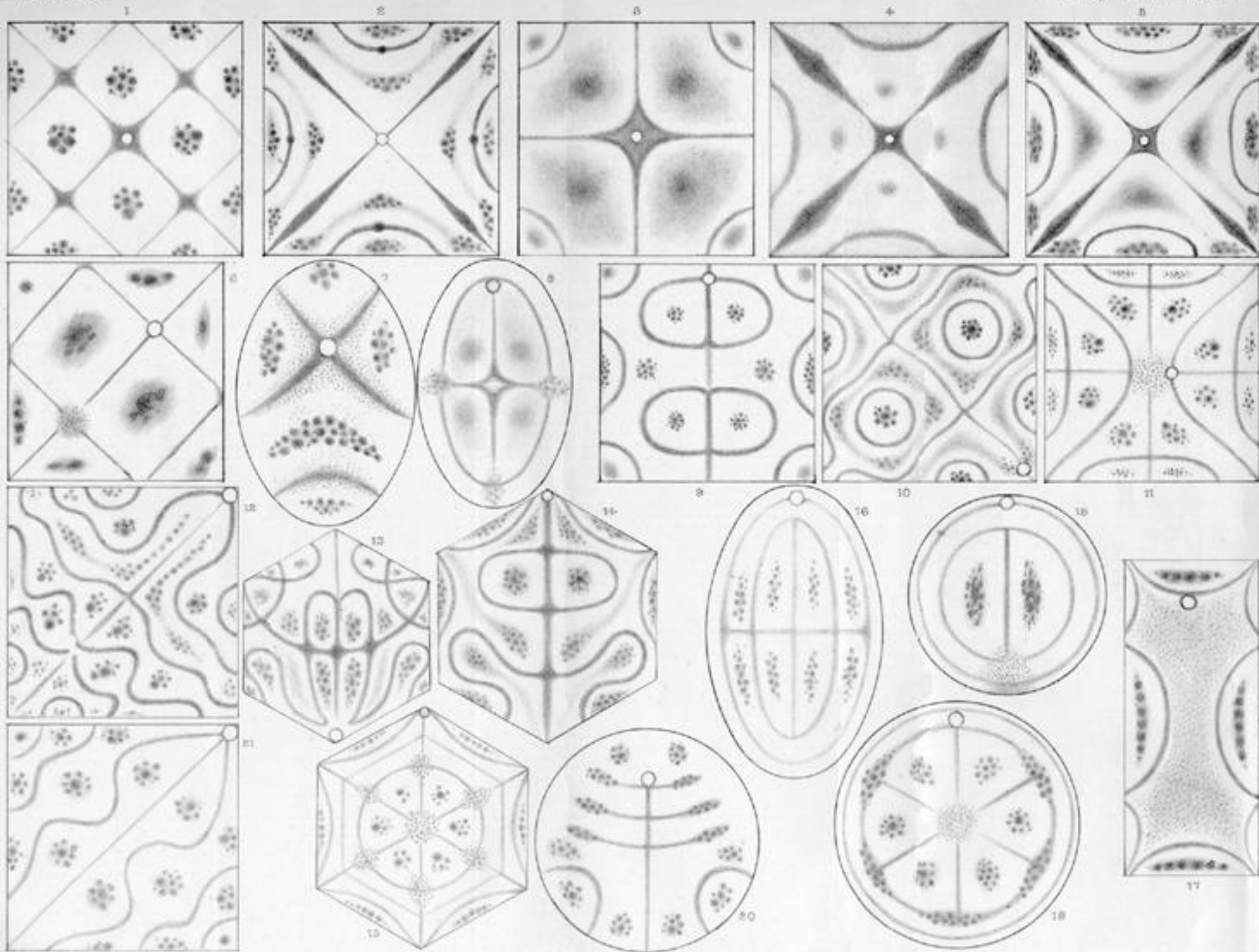
NOTE.—When the plate is clamped near the edge, the bow should be applied as near to the clamp as may be convenient. If far removed therefrom, the amplitude of the vibrations is too great to produce a good figure, and glass plates are liable to be broken.

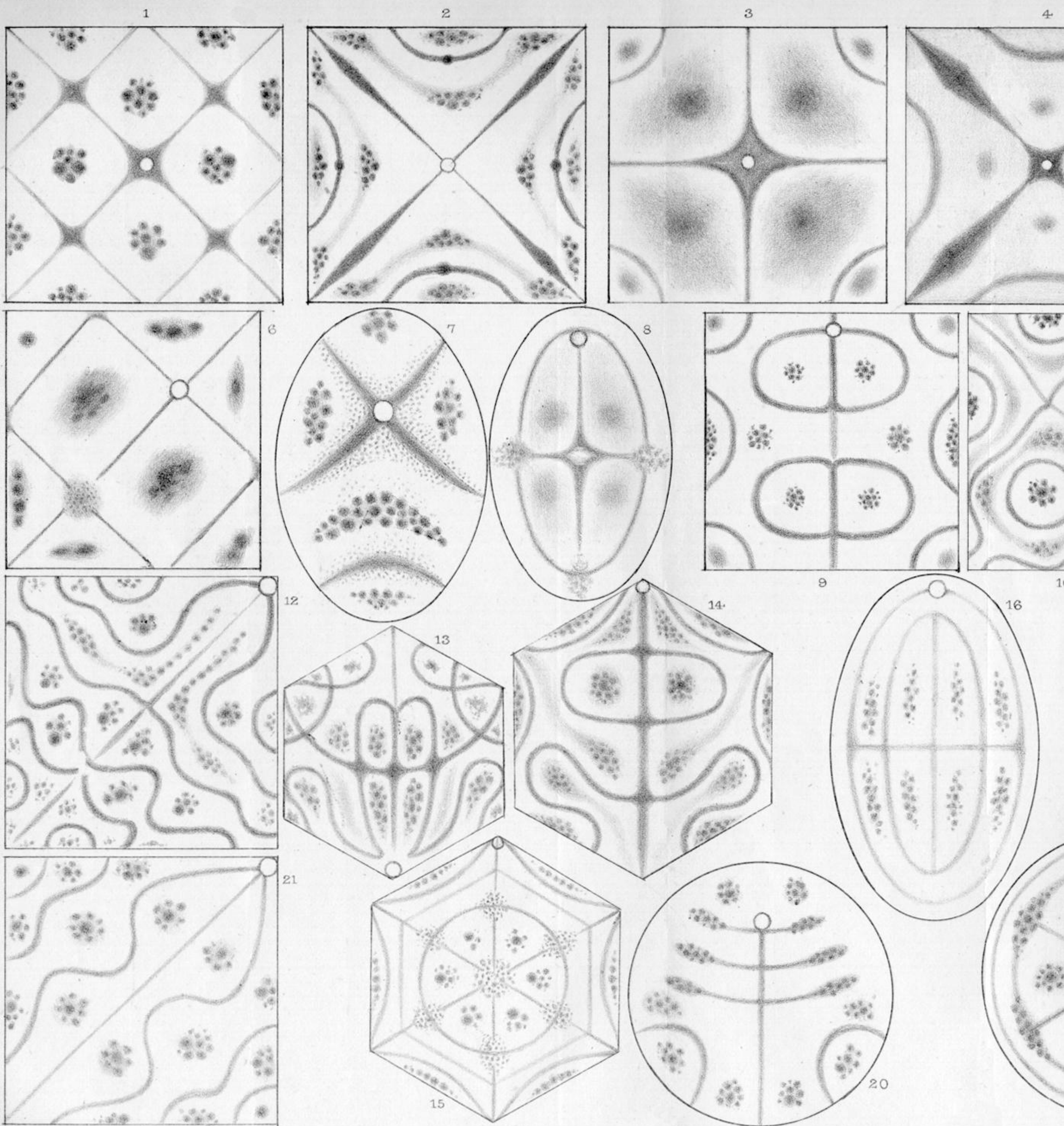
Tomlinson.



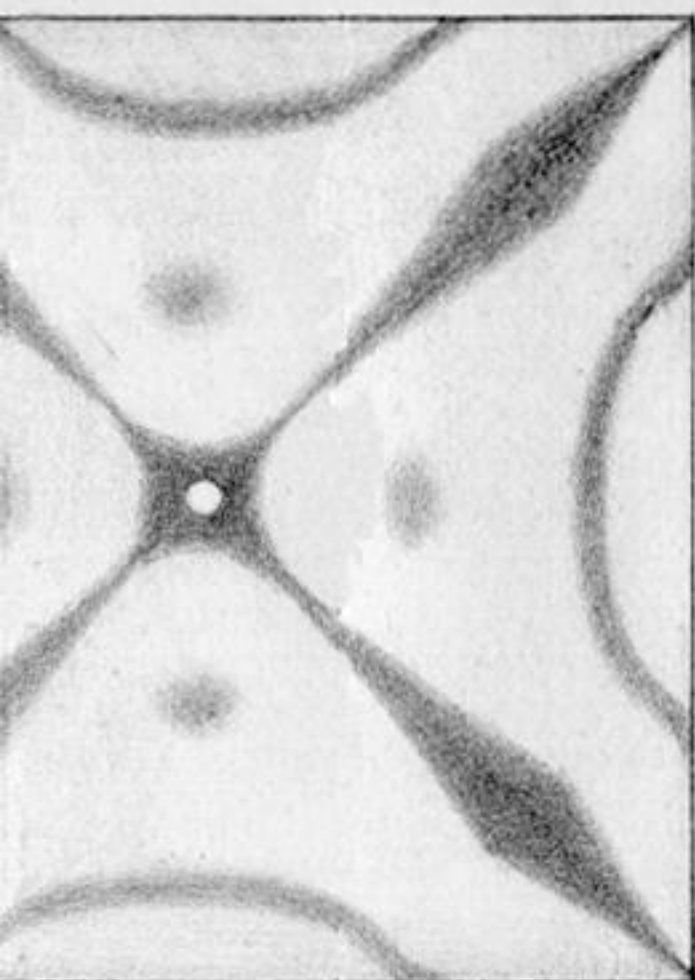
Mary Tomlinson del^l



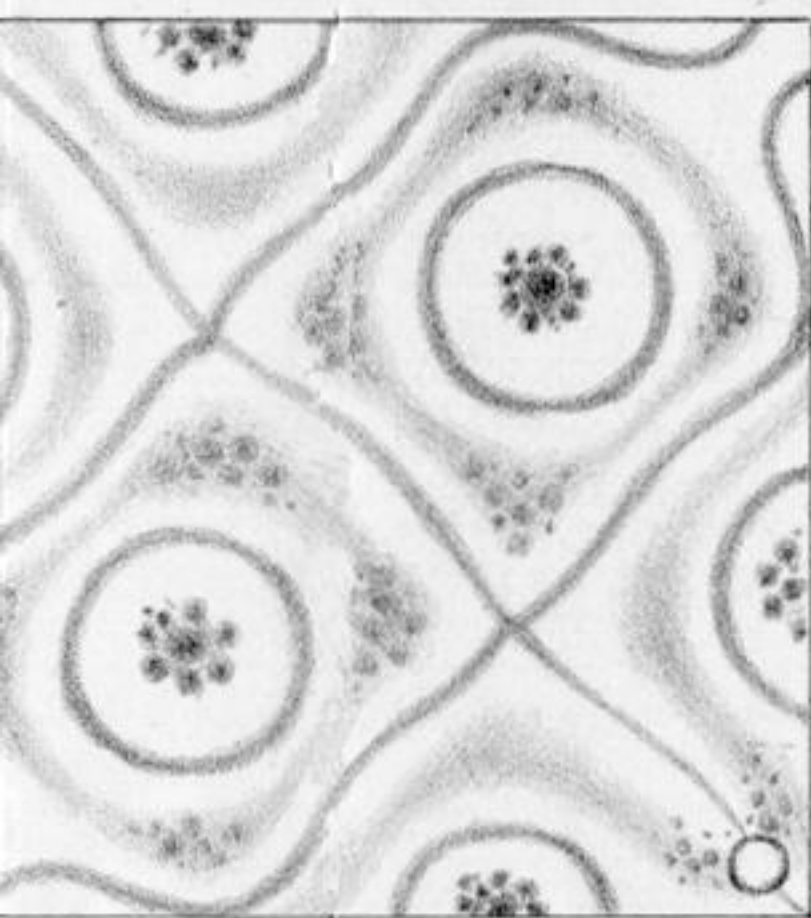
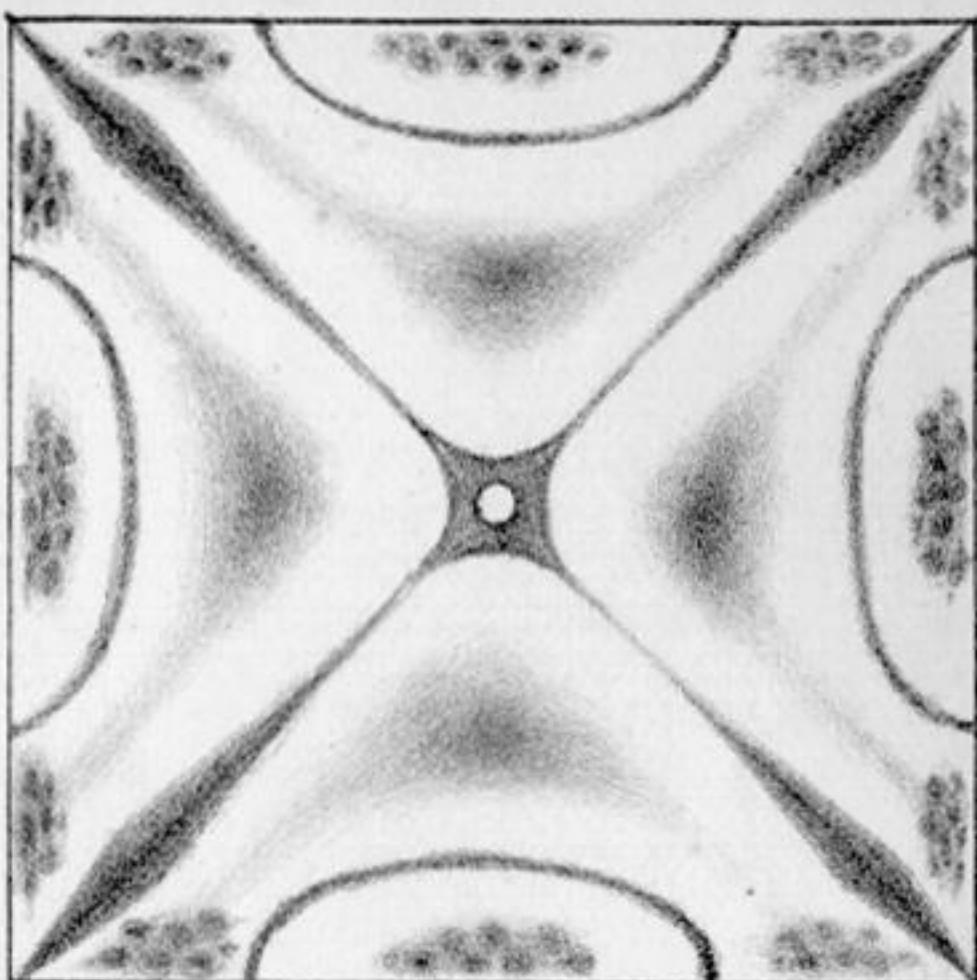




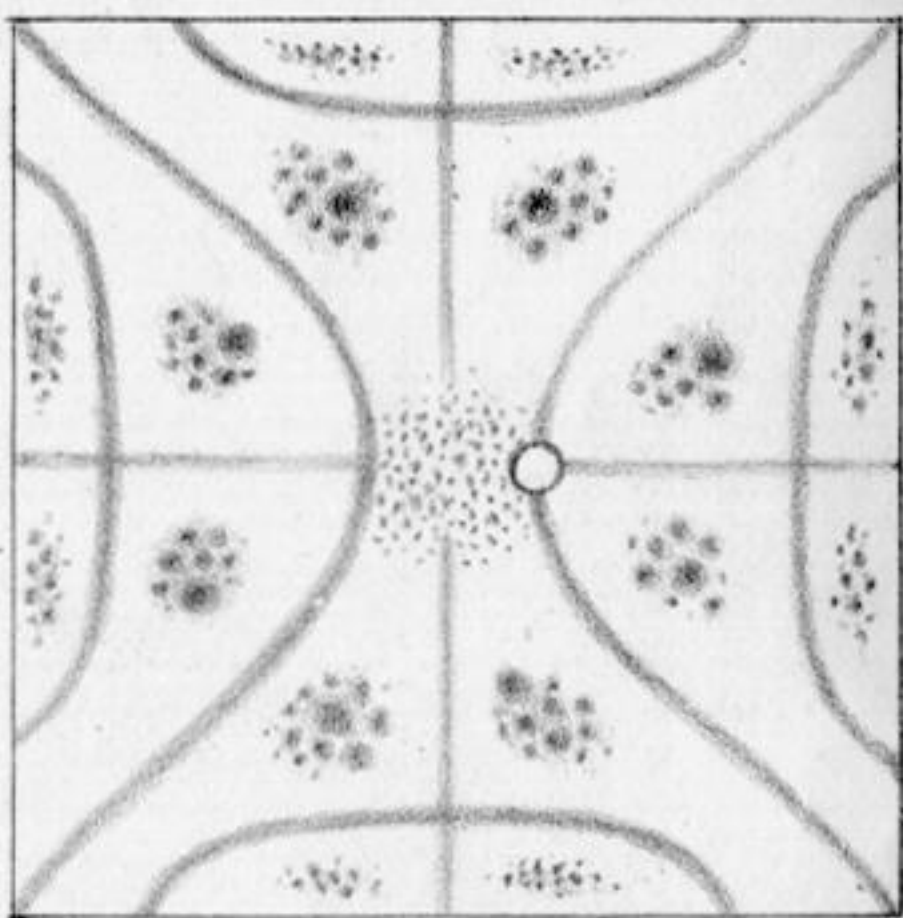
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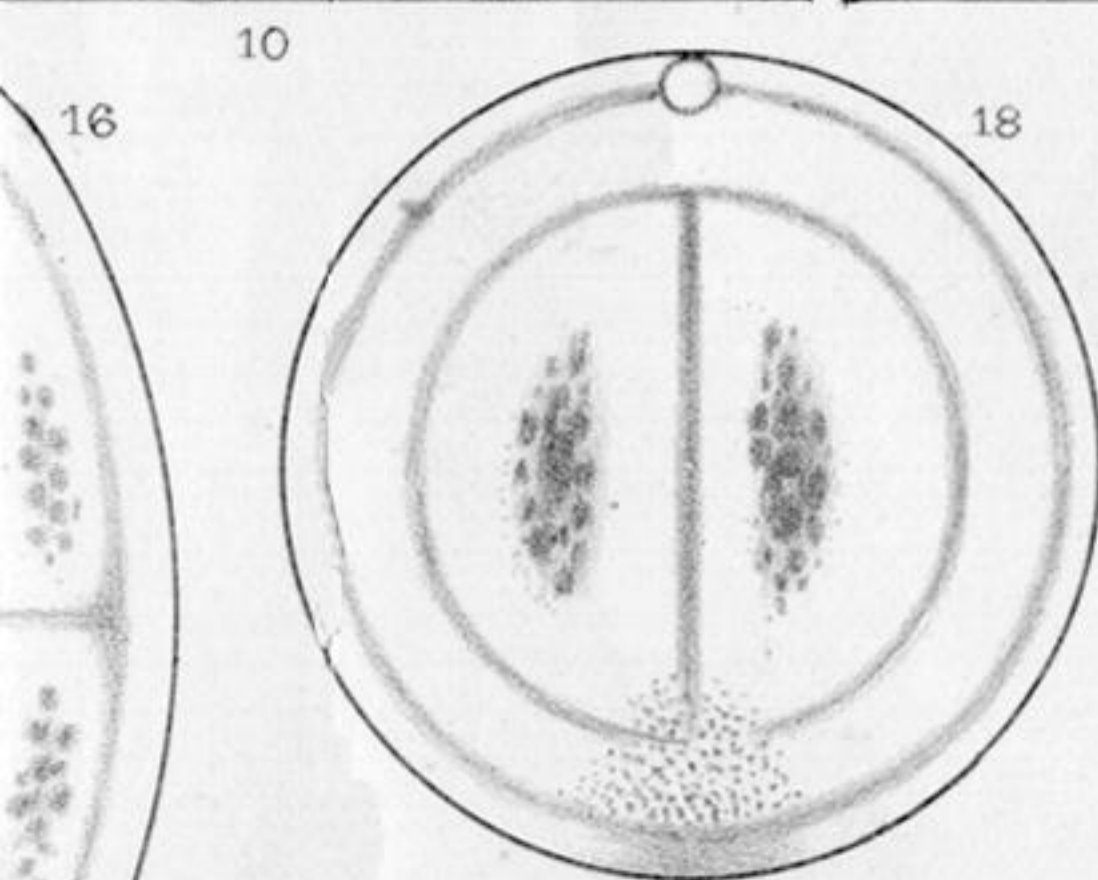
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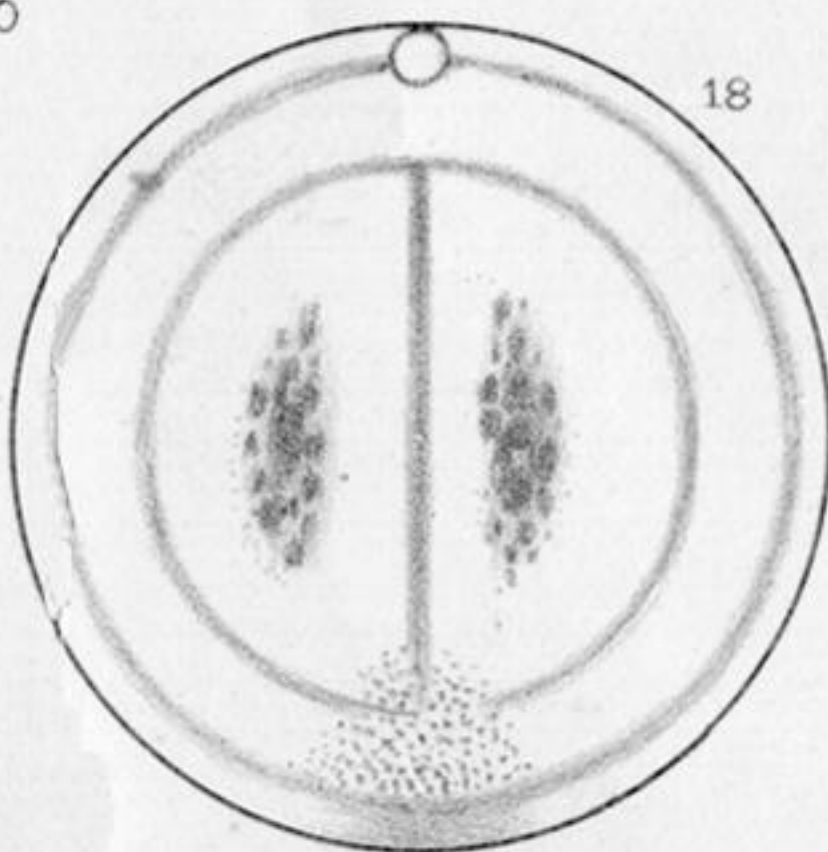
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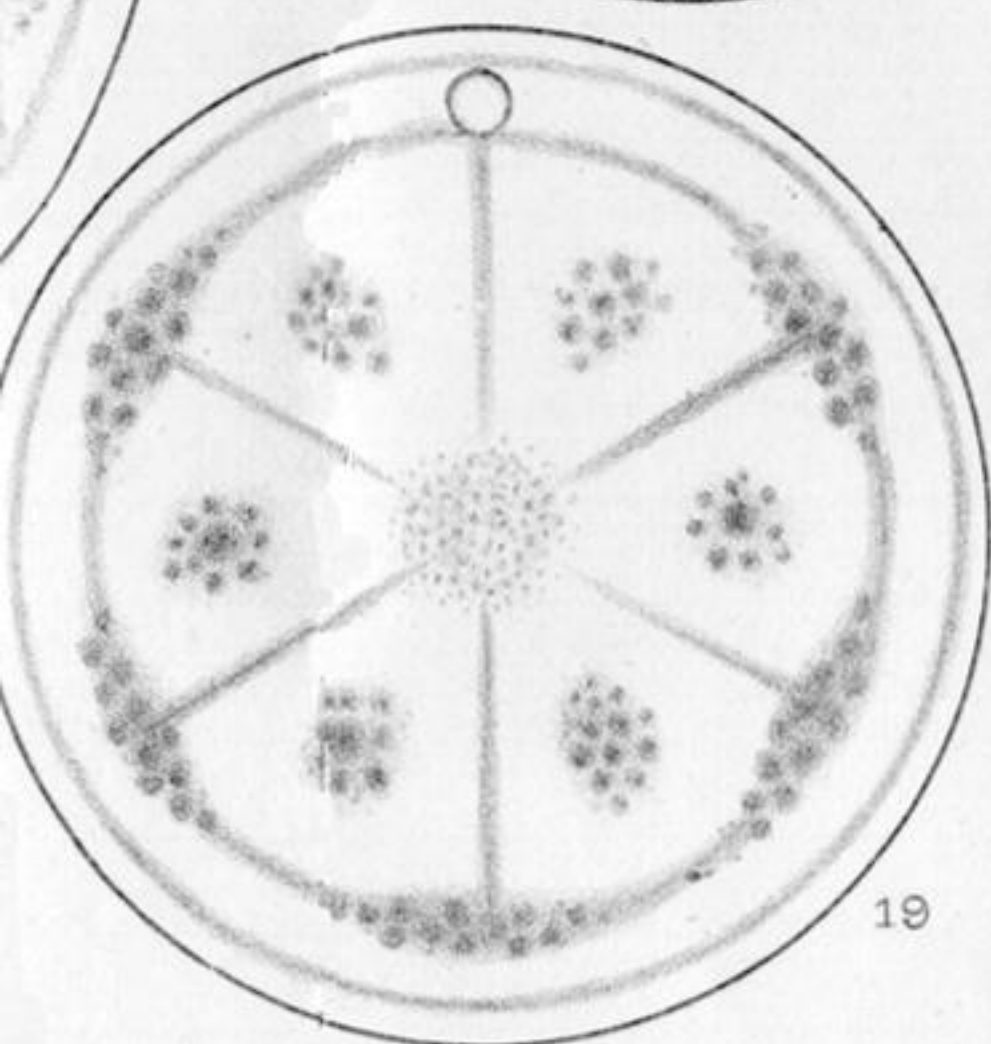
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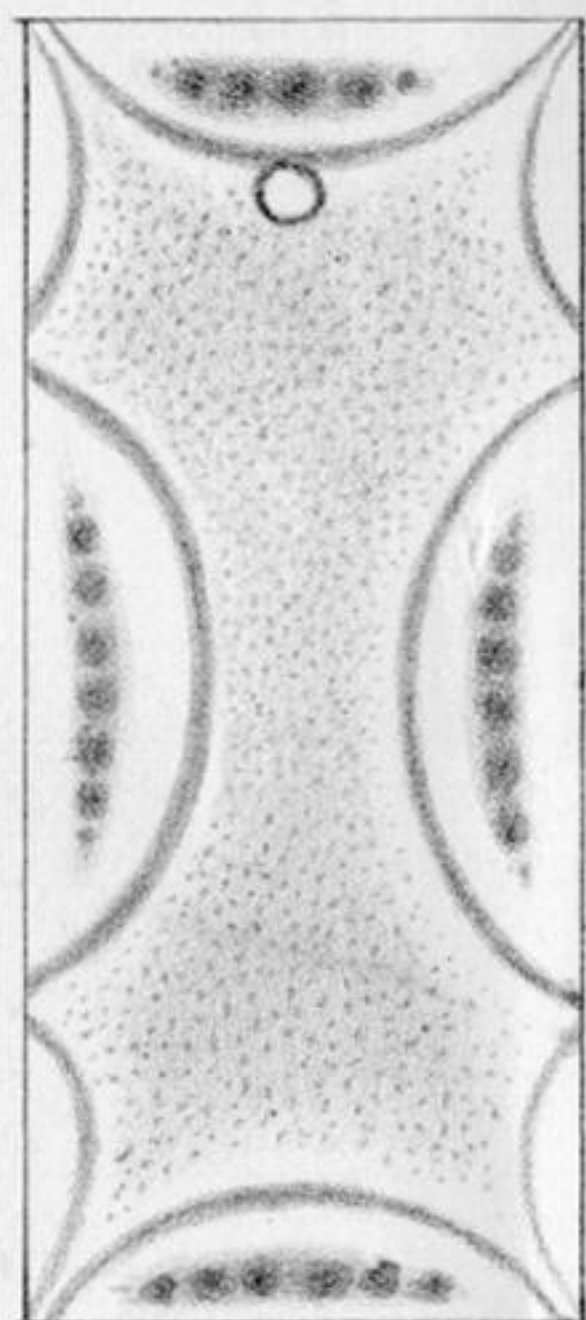
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